

The University of Chicago

A STUDY OF OSCILLATION AS A
UNITARY TRAIT

A PART OF A DISSERTATION SUBMITTED TO THE
FACULTY OF THE DIVISION OF THE SOCIAL
SCIENCES IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATION

1936

By
MARIAN EAST MADIGAN

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INTRODUCTION

No one can "attend" continuously to a task. With the best of attention output fluctuates. Flugel showed that people who oscillate widely in one thing tend to oscillate widely in all things, and vice versa. It was on the basis of this investigation that Spearman, applying the criterion of tetrad differences laid claim to a general factor of oscillation, symbolized by him as "o"¹.

THE PROBLEM

This paper represents an attempt to investigate rather thoroughly the behavior-unit of oscillation. More explicitly stated, its purpose is to apply the scheme of intercorrelations, tetrads, and factorial analysis, in connection with other variables, to ascertain the existence of oscillation as a unitary trait. Closely akin to the main problem will be the consideration of the validity and reliability of the oscillation tests, the effect of two methods of scoring them, and a comparison of oscillation of children with that of adults.

Data

Some thirty variables centering around the assumed factors of oscillation, perseveration, spatial relations, mental speed, motor speed, attention, fluency, and memory were selected. This battery was given to 117 adults, the majority being graduate students.

The tests utilized in this study were some of those previously administered to school children in the Spearman-Holzinger unitary traits study². In the oscillation series, Test 42 was made up of clusters of dots, Test 43 utilized capital letters, Test 44 made use of segments of "X" and a "□", Test 45 was comprised of a series of digits, and Test 46 consisted of the segments of "X", a "□", and "W". The first four tests have their content distributed along zigzag lines which twist irregularly back and forth across a page,

18 × 14. The symbols in Test 46 were distributed in straight lines across the page.

In Test 42, the subject was to count the number of dots; in Test 43 he was to distinguish between capital letters made entirely of straight lines and those involving curved lines; the task in Tests 44 and 46 was to identify the symbols to which the segments belonged; and in Test 45 the subject was to add the digits by twos, putting down only the units figure.

Experimental set-up

Preliminary investigations in administering the oscillation tests as group tests had resulted in the waste of a large amount of data. In order to minimize this loss and secure reliable data, the oscillation tests were administered individually. The remainder of the battery was administered as group tests.

Since measures of "o" were to be derived from the variation in output of precise units of mental work, an accurate automatic timing device was arranged which clicked off intervals of five seconds. The subject was admonished to work as rapidly as possible in order that speed could be kept constant. He was carefully instructed to put a tick-mark on his paper at the place where he was working when the hammer clicked and then continue working at top speed. In the effort to maintain top speed some of these interval-marks were omitted. It was the business of the examiner to note carefully their omissions and insert them after each test. Good records of responding were thus secured in every case. The administering of the "o" tests individually, not only made for better responding, but it allowed the subject to complete each test. A short form, approximating about half the content of the long form, preceded each "o" test.

VALIDITY AND RELIABILITY

Validation

Internal consistency among supposedly related variables was the basis on which validation was studied. If four or more measures

¹ C. Spearman, *The Abilities of Man*. New York: Macmillan Co., 1927, Pp. 324-326.

² *Preliminary Report on Spearman-Holzinger Unitary Trait Study, No. 1*. Prepared at the Statistical Laboratory, Department of Education, University of Chicago, 1934.

correlate positively, then there is justification for postulating a trait which is indicated by each of the measures³. Intercorrelations for both the short and the long forms were considered.

The average of the ten intercorrelations for the short forms was .2072 and the average for the long forms of the same set was .4190. However length was not the only factor making for the increase in the intercorrelations. The average intercorrelations showed that a test of 60 five-second intervals yielded as good results as one 180 five-second intervals in length. Inasmuch as the number of different tasks in each test was relatively few, thereby making for a great deal of repetition throughout the test, the set of "o" tests was considered relatively constant in difficulty. On the assumption that these tests measure oscillation, and the intercorrelations lend support to this, it would seem that the better intercorrelations are due to the content of the tests. Ranking first, is Test 43.

Scoring was based on the mean deviation formula and the method of differences. In this latter method, if a subject's output were constant, there would be no differences, but as his output fluctuates the absolute change from interval to interval is summed and divided by the number of intervals for his score. Flugel makes the statement that he adopted this method instead of the mean deviation

"both because of its greater simplicity from the point of view of calculation and because the measure of variability obtained by such a method is relatively unaffected by a constant tendency of the value to rise or fall—such a constant tendency being of course present in our data in the shape of fatigue."⁴

To the writer this suggested that intercorrelations secured by this method would be higher than by the deviation formula. The comparison was made on the basis of the longer forms because fatigue would be expected to be present to a greater extent than on short forms. The results in Table I do not support the investigator's interpretation.

"Holding amount constant" means that the subject finished the test regardless of time. "Time constant" basis is the time that it took the fastest subject to complete the test. In

this situation the results are calculated on the same number of intervals varying per test.

A comparison of the results in Table I show the averages for the "Time Constant" basis to be lower. That is, the length of the test has been reduced and in all but three instances, the correlations are lower.

From the foregoing results, it is evident that the validity of oscillation tests on the basis of internal consistency depends on length. That is, other things being equal, the longer the tests the better the inter-correlations resulting therefrom. But investigations reveal that beyond 60 five-second time intervals, "o" tests do not yield increasingly better results commensurate with the time and labor involved. Of the two methods of scoring, the results favor the mean deviation method.

Reliability

Since the "o" tests are the continuous function type of test, alternate items or intervals could not be used. Therefore it was necessary to use the first half of the test and compare it with the second half. Since the content of the tests was of the same level of difficulty throughout, it does not seem that it would be objectionable to use continuous halves for a basis of reliability.

The primary purpose in administering the short forms of each "o" test was to thoroughly acquaint the subject with the test before taking the long form. It so happened that the content of the short form was identically repeated in the beginning of the long form. By cutting the long tests off to parallel the content of the short tests, two identical forms of the same test were available. Since the long form doubled the content of the short form in three tests, this allowed an empirical check on the use of the Spearman-Brown formula. The other tests were about one and a half times their short forms.

One of the most illuminating bits of evidence from a study of these results in Table II is the fact that the average of the correlations by identical forms is practically the same as the average resulting from the reliability of the long forms. It is the opinion of the writer that such a comparison as this yields conclusive evidence bearing on practice effects. There was no intention in the mind of the examiner to hold practice effects at a minimum. In this case they might well be considered at a maximum since the short

³ L. L. Thurstone, *The Reliability and Validity of Tests*, p. 101. Ann Arbor, Michigan: Edwards Brothers Inc., 1932.

⁴ J. C. Flugel, *Practice, Fatigue, and Oscillation*. The British Journal of Psychology Monograph Supplement, No. 13, p. 66. Cambridge University Press, 1928.

TABLE I
CORRELATIONS OF "O" TESTS BASED ON TWO DIFFERENT METHODS OF SCORING
Amount Held Constant Basis

Test	Mean Deviation Method				Flugel's Method			
	43	44	45	46	43	44	45	46
42 -----	.3051	.3062	.3908	.3375	.3171	.2365	.4339	.3280
43 -----		.5100	.4557	.5086		.4630	.3962	.4385
44 -----			.4003	.4928			.4199	.4200
45 -----				.4826				.4083
Ave.-----		.4190				.3861		

Time Held Constant Basis

Test	Mean Deviation Method				Flugel's Method			
	43	44	45	46	43	44	45	46
42 -----	.2747	.1795	.3477	.3059	.2948	.1961	.3973	.2691
43 -----		.4464	.4345	.4981		.4253	.3069	.4209
44 -----			.3153	.3670			.2871	.3078
45 -----				.4939				.3545
Ave.-----		.3663				.3260		

forms approximated half the content of the long forms. Such evidence as this should allow the experimenter to provide ample practice periods for subjects with no fear of practice effects.

Corresponding halves of these "o" tests were correlated and stepped-up by the Spearman-Brown formula to note their comparisons with the intercorrelations resulting from the complete tests. On the "Amount Held Constant" basis the average of the intercorrelations on the first half of each test was .4554. For the second half it was .4914. The average of the intercorrelations on the complete tests was .4188. On the "Time Held Constant" basis, these averages were respectively .4332, .3892, and .3605. Thus, the Spearman-Brown formula applied to corresponding halves is sensitive enough to yield

results differing by only .03 to .07 from those obtained from the complete tests.

The results of this section indicate that the "o" tests are stable in yielding reliability coefficients of the same magnitude on the continuous half method as well as on identical forms. Practice effects are negligible and length plays relatively the same role in reliability as in validity. The Spearman-Brown formula applied to intercorrelations of corresponding halves yields results similar to those obtained from the complete tests.

THE EFFECT OF INCREASING THE TIME UNIT ON THE MEASUREMENT OF OSCILLATION

The results of a preliminary investigation of 25 cases on varying the time unit, pointed to the operation of a law in measuring oscillation. The possibilities inherent in such an

TABLE II
RELIABILITY OF 117 CASES OF "O" TESTS INVOLVING TWO DIFFERENT METHODS OF SCORING:
ALL RESULTS STEPPED UP BY THE SPEARMAN-BROWN FORMULA

Test	Mean Deviation Method			Flugel's Method	
	Identical Forms	Amt. Held Constant	Time Held Constant	Amt. Held Constant	Time Held Constant
42 -----	.6178	.4961	.5857	.5215	.4937
43 -----	.6943	.7615	.6609	.6937	.6005
44 -----	.5941	.6727	.5209	.5967	.4322
45 -----	.6610	.6695	.6897	.6921	.6029
46 -----	.6834	.6563	.6563	.4943	.4943
Ave.-----	.6501	.6512	.6227	.5997	.5247

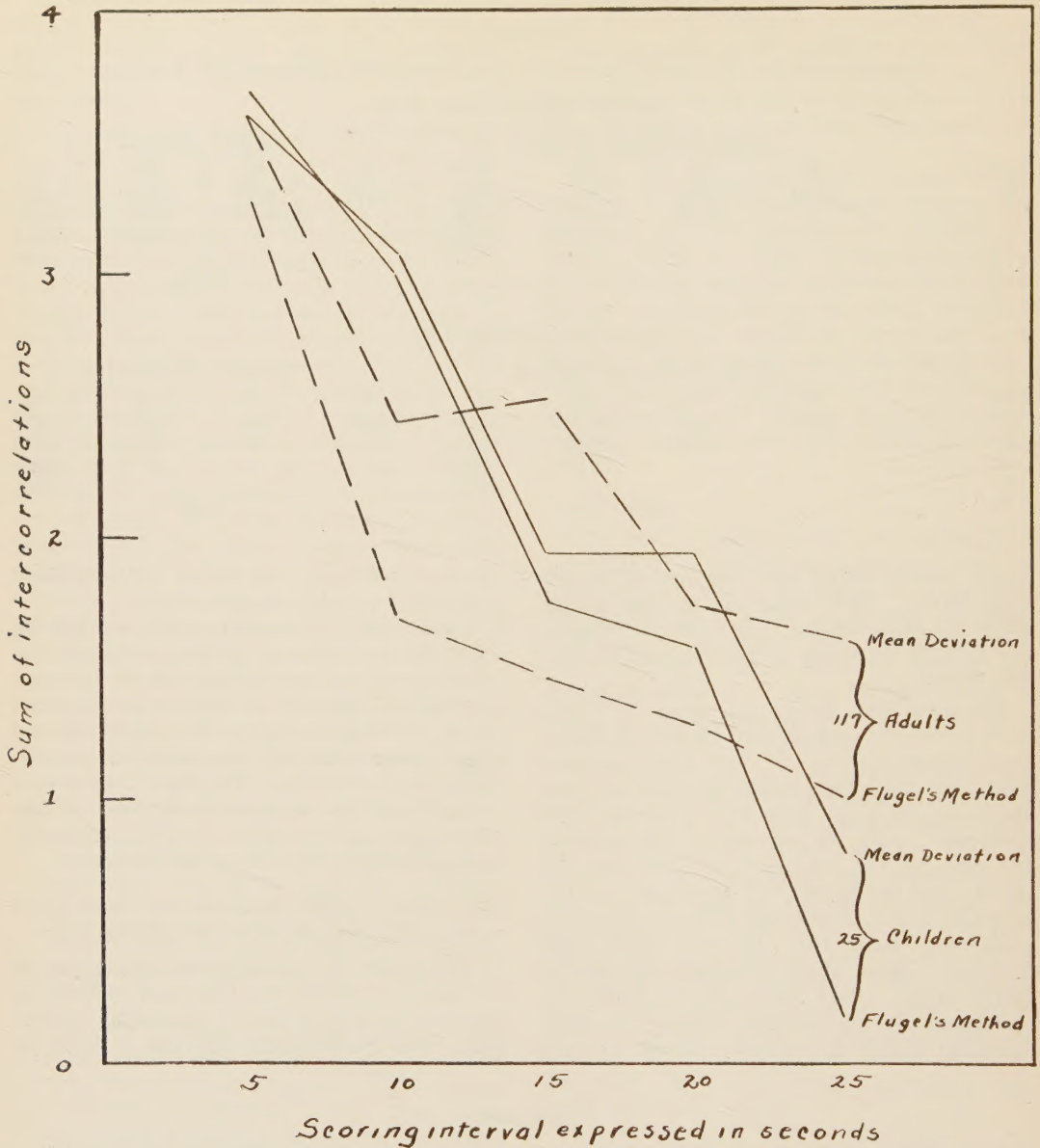


Figure 1.—The graphs of oscillation for children and adults based on two methods of scoring on varying time units.

operative factor warranted an investigation on the larger sample of 117 cases.

Basis of Procedure

The oscillation tests were scored on the basis of 5-, 10-, 15-, 20-, and 25-second intervals. Two methods of scoring were investigated.

In order to provide the same length for all

subjects on a test, the "Time Constant" basis was used. Three tests were approximately 45 five-second intervals in length while the other two were 70 and 114 five-second intervals. The last step involved the intercorrelations of these scores on the five different time units according to the two methods of scoring.

Interpretations

The preliminary investigation dealt with children, the 117 cases with adults. In Figure 1, the graphs have been displayed together. It is obvious that scoring by either method on the smallest available time unit yields the best results. One might raise the question as to how small this unit of time ought to be in order to produce the maximum measure of "o". Beyond a 15-second interval, the "o" scores tend rapidly toward zero.

The parallelism of the two methods comes between the 10-second and the 15-second intervals as well as between the 20- and 25-second intervals for children while the plateau in the mean deviation method occurs between the 15- and 20-second intervals. But in the graphs of the adults, the parallelism occurs between the 5- and 10-second intervals and the plateaus come between the 10- and 15-second intervals. The almost direct downward descent in Flugel's method for children starts at the 15-second interval while a somewhat smoother descent starts at the 10-second interval for adults. Likewise the sharp descent of the mean deviation method for children operates at the 20- to 25-second interval while a smoother descent operates at the 15- to 20-second interval for adults.

It is such evidence as this that points to the idea that perhaps maturation may be involved in this factor of oscillation. The more natural tendency has been conditioned by experience until it takes a finer unit of measure to ascertain its presence.

FACTOR ANALYSIS OF THE DATA

The factor analysis of these data proceeds according to the Two-Factor method of Spearman. Aside from using the tetrad criterion, residuals were resorted to most freely. Residuals should be insignificant if the tetrads vanish for the set of variables. The agreement of possible factors with that of the large residuals has been shown to be sufficiently accurate for the allocation of suspected extra factors.⁵ Whenever critical points arose, tetrads were used as a check. Thus the tedious task of computing thousands of tetrads was eliminated, the method of residuals and, if necessary, the formulation of more than one pattern proving the more expedient.

⁵ Spearman-Holzinger, *Preliminary Report on the Unitary Trait Study*, No. 2, p. 23. Prepared at the Statistical Laboratory, Department of Education, University of Chicago, 1934.

Indications of Factors

The intercorrelations of the 29 variables in general show a high degree of consistency amongst the clusters of tests for each assumed factor and, with the exception of mental speed, the correlations amongst the tests representing different assumed factors are low. Tetrads for each of these other sets of four or more variables are generally significant. If it were not for this overlap, the large value of r_{pj} for mental speed would indicate a satisfactory measure of such a composite. With the exception of the perseveration tests, the poolings in Table III indicate that measures of the various assumed factors are fairly satisfactory. Such evidence as this allows one to proceed with the factorization of the data.

TABLE III

TETRADS AND CORRELATIONS r_{pj} FOR EACH ASSUMED FACTOR

Assumed Factor	P. E. largest tetrad in set	r_{pj}
Spatial -----	P. E. (—0.0151)	.0271 .9388
Mental Speed ---	P. E. (.2356)	.0138 .9556
Motor Speed ----	P. E. (.0944)	.0537 .8500
Perseveration ---	P. E. (—0.0462)	.0116 .7024
Oscillation -----	P. E. (.0772)	.0329 .8946
Attention -----	P. E. (—0.1095)	.0312 .8637

The Patterns

The true factor pattern for any set of variables is probably very complex. The chief guiding principle in selecting a factor pattern is to try the simplest one first. A considerable number of patterns might be formulated as defensible explanations of underlying correlations.⁶ The arrangement of these patterns determines the order in which factors are removed and since the first factor removed is generally favored, there arises a certain amount of ambiguity in the results. This ambiguity has been removed by Holzinger⁷ in the formulation of the "hollow staircase" type. In this pattern, after the principal factor has been removed, the remaining factors may be taken out in any order and the factor loadings will not change their order of magnitude.

The investigator set up four patterns. Pattern A involved four tests of a kind for five of the factors and five tests for the "o" factor. Pattern B dealt with the consideration of an overlap between space and attention, in-

⁶ K. J. Holzinger and F. Swineford, "Uniqueness of Factor Patterns", *Journal of Educational Psychology* XXII (1932), 247-58.

⁷ Spearman-Holzinger, *Op. Cit.*, No. 5, p. 5.

volving the same variables as in Pattern A. Only five factors were dealt with in Pattern C, the perseveration tests being omitted because of their low intercorrelations and the wide fluctuation with other variables. Pattern D was applied to all 29 variables. The two extra tests, memory and fluency, were allocated to one of the six assumed factors on the basis of their correlations. With the exception of Pattern B, the "hollow staircase" type was used.

Results of the Four Patterns

In order to secure a basis of comparison for the secondary factors throughout each of the four patterns, the average variance for each of the factors was calculated. The results are summarized in Table IV.

TABLE IV

THE VARIANCE OF THE GENERAL FACTOR, THE SECONDARY FACTORS, AND THE SPECIFIC FACTORS FOR FOUR PATTERNS

Pattern	Per Cent of Variance of Factors		
	General	Secondary	Specifics
A -----	16.62	23.00	55.37
B -----	15.39	29.23	55.38
C -----	21.36	29.54	49.09
D -----	18.56	24.76	56.68

Undetermined specifics claim from 49 to 57 percent of the factor weights while the general factor variance in no case exceeds the variance of the secondary factors. In Pattern B the variance of the secondary factors is nearly double that of the general factor. Evidently the assumption of a spatial-attention factor has not increased the specifics but has favored the secondary factors at the expense of the general factor. The elimination of the poor set of "P" tests in Pattern C has decreased the specifics and increased the general factor. In many instances the general factor loadings for a test exceed those of the secondary

factor. It is this overshadowing of the secondary factors that makes it highly desirable to be able to analyze or split-up this general factor into more specific and meaningful components.

It seems fitting to comment at this point on the recent findings of the Committee on Unitary Traits. Mr. Holzinger remarks as follows:

In attempting to analyze the U_1 (general) factor we have eliminated Grade as well as Age . . . comparing this . . . wherein only Age has been eliminated, we find that the weights of U_1 drops from 28.81 per cent of variance . . . to only 14.21 per cent . . . These results are very promising because they indicate the possibility of resolving the U_1 factor into a number of basic maturity factors.³

The fact that the general factor variance in all four patterns of this study does not in any instance equal the amount of the secondary factor variance would tend to support the findings of Mr. Holzinger. The subjects of the present investigation were adults. Would not age and maturation in this case be minimized thereby reducing the general factor loadings and increasing the secondary weights?

The relative importance of the secondary factors are given in Table V. It is evident from this table that of all 29 variables studied, the spatial and "o" tests are the best devised because they are more highly saturated with what they are supposed to measure. Even at that, the saturation amounts only to approximately 40 per cent. Thus the big problem for the factorists still remains,—that of devising tests that produce high saturations of what they are intended to measure.

³ Spearman-Holzinger, Op. Cit., No. 6.

TABLE V

AVERAGE LOADINGS FOR SECONDARY FACTORS FROM FOUR PATTERNS

Factor	Pattern				Average
	A	B	C	D	
Spatial -----	.4458	.3711	.4342	.3670	.4045
Mental Speed -----	.3062	.3326	.2685	.2281	.2839
Motor Speed -----	.1551	.0935	.1910	.1154	.1383
Perseveration -----	.1664	.1763	-----	.1419	.1615
Oscillation -----	.3868	.3672	.3950	.4067	.3889
Attention -----	.1958	-----	.1640	.1930	.1843
Spatial Attention -----	-----	.1972	-----	-----	.1972

The Magnitude of the Final Residuals for the Four Patterns

Table VI shows the distribution of the residuals for each pattern with their means, standard deviations, and probable errors. The smallest mean, almost zero, occurs in Pattern D where there are the greatest number of residuals recorded. It is interesting to note that the highest mean occurs with the lowest frequency and with the increase of the number of residuals, the mean decreases. This indirect variation would seem to indicate that the variation in the mean is due to chance.

With only a difference of .0081 between the highest and lowest standard deviation, each pattern may be considered as an equally good fit: The slight increase in Pattern D is probably due to the allocation of extra factors. The elimination of the perseveration tests yielded a slightly lower standard deviation in Pattern C but not enough to be judged significant.

Multiplying the standard deviation of each pattern by .6745 and comparing them with

the P. E. of zero correlation for 117 cases, the P. E. of the standard deviations are all less than the probable error of zero correlation. Using this as a rough basis of approximation, one can say that the final residuals of each pattern may be considered negligible.⁹

The indications of factors by the various statistical techniques has been verified by the resulting factor patterns. Each pattern, judging by the P. E. of its standard deviation compared with the P. E. of zero correlation for the same number of cases, could be considered a good fit. The spatial and "o" tests were most highly saturated with their respective factors.

SUMMARY AND INTERPRETATIONS

The findings presented in this study lead to the following conclusions:

(1) Length up to about 60 five-second intervals for "o" tests is sufficient to secure a good measure of "o". Good reliability re-

⁹ Spearman-Holzinger, *Op. Cit.*, No. 4, pp. 3-4.

TABLE VI

FREQUENCY DISTRIBUTIONS OF FINAL RESIDUAL CORRELATIONS FOR PATTERNS A, B, C, AND D				
Value of Residual	Pattern A	Pattern B	Pattern C	Pattern D
.2700 ----- .2899 -----		1		
.2500 -----	1		1	2
.2300 -----		2		1
.2100 -----	1	2		2
.1900 -----	4	2	1	1
.1700 -----	5	5	3	10
.1500 -----	7	6	6	5
.1300 -----	7	8	8	14
.1100 -----	12	10	6	14
.0900 -----	15	22	11	17
.0700 -----	19	18	18	20
.0500 -----	25	20	19	24
.0300 -----	22	22	7	38
.0100 -----	17	24	23	32
-.0100 -----	42	39	29	35
-.0300 -----	29	26	13	43
-.0500 -----	20	25	16	34
-.0700 -----	25	21	20	30
-.0900 -----	14	15	11	30
-.1100 -----	11	9	6	10
-.1300 -----	2	5	3	14
-.1500 -----	6	5	3	6
-.1700 -----	6	9	1	11
-.1900 -----	5	1	2	4
-.2100 -----	3	2	2	5
-.2300 -----	1		1	1
-.2500 -----		1		3
-.2700 ----- .2501 -----	1			
Total -----	300	300	210	406
Mean -----	.0074	.0118	.0130	.0004
S. D. -----	.0842	.0872	.0826	.0907
.6745 × S. D. -----	.0568	.0588	.0557	.0612
P. E. zero correlation -----	.0624	.0624	.0624	.0624

sults are secured from oscillation tests 60 to 75 five-second intervals in length.

(2) The application of the Spearman-Brown formula to the continuous halves of the "o" test in general predicted results comparable with the intercorrelations of the complete tests.

(3) Practice in no way affects the scores on the "o" tests.

(4) The mean deviation method for scoring the "o" tests proved superior to Flugel's method in both validity and reliability.

(5) The narrowness of the time unit in scoring proved to be a most significant fact both in securing good measures of "o" and in yielding good reliability coefficients.

(6) The graphs of the two sets of data for

oscillation from adults and children reveal similar characteristics.

(7) There is some evidence to show that children oscillate over a wider range than do adults.

(8) The poolings of the "o" tests as well as their factor weights indicate that they are fairly good measures of "o".

In general the facts indicate that "o" is a very sensitive behavior-unit. Only by narrowing the time basis can the individual differences of this trait be measured. Oscillation turns out to be a very definite component in human abilities as revealed by the factor loadings,—the tests being saturated with the "o" loadings and possessing but small loadings with the general factor.

